NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

(NASA-Case-MFS-21462-1) INHERENT REDUNDACY ELECTRIC HEATER Patent (United Aircraft Corp., West Palm Beach, Fla.) 4 p CSCL 09E

N74-14935

Unclas
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TO: KSI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3 732 397

Government or Corporate Employee : United Aircraft Corp. West Palm Beach, FL

Supplementary Corporate Source (if applicable) :

NASA Patent Case No. : MFS-21462-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes [X] No [ ]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

Elizabeth A. Carter
Enclosure
Copy of Patent cited above

NASA-HQ

United States Patent [19]

Fletcher et al.

[11] **3,732,397**

[45] **May 8, 1973**

[54] **INHERENT REDUNDACY ELECTRIC HEATER**

[76] Inventors: **James C. Fletcher,** Administrator of the National Aeronautics and Space Administration with respect to an invention of; **Bruce H. Kernodle,** Palm Beach Gardens, Fla.

[22] Filed: **Mar. 30, 1972**

[21] Appl. No.: **239,576**

[52] **U.S. Cl.** **219/477,** 219/539, 338/320

[51] **Int. Cl.**.....**H05b 1/02**

[58] **Field of Search**.....219/483, 484, 485, 219/486, 476, 477, 478, 539; 338/261, 298, 299, 319, 320

[56] **References Cited**

UNITED STATES PATENTS

432,932	7/1890	Burton	219/477
743,654	11/1903	McElroy	219/477
838,884	12/1906	McElroy	219/539
1,689,432	10/1928	Hartwig	219/477

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Attorney—L. D. Wofford, Jr. et al.

[57] **ABSTRACT**

A cross-wound electrical heater comprising two resistance coils wound together with opposite pitches and electrically connected at their crossing points. Each element is supplied by a separate power supply of the same magnitude, and each power supply is isolated from reverse currents by a diode. Failure of one of the windings results in only a moderate change in output power.

9 Claims, 3 Drawing Figures

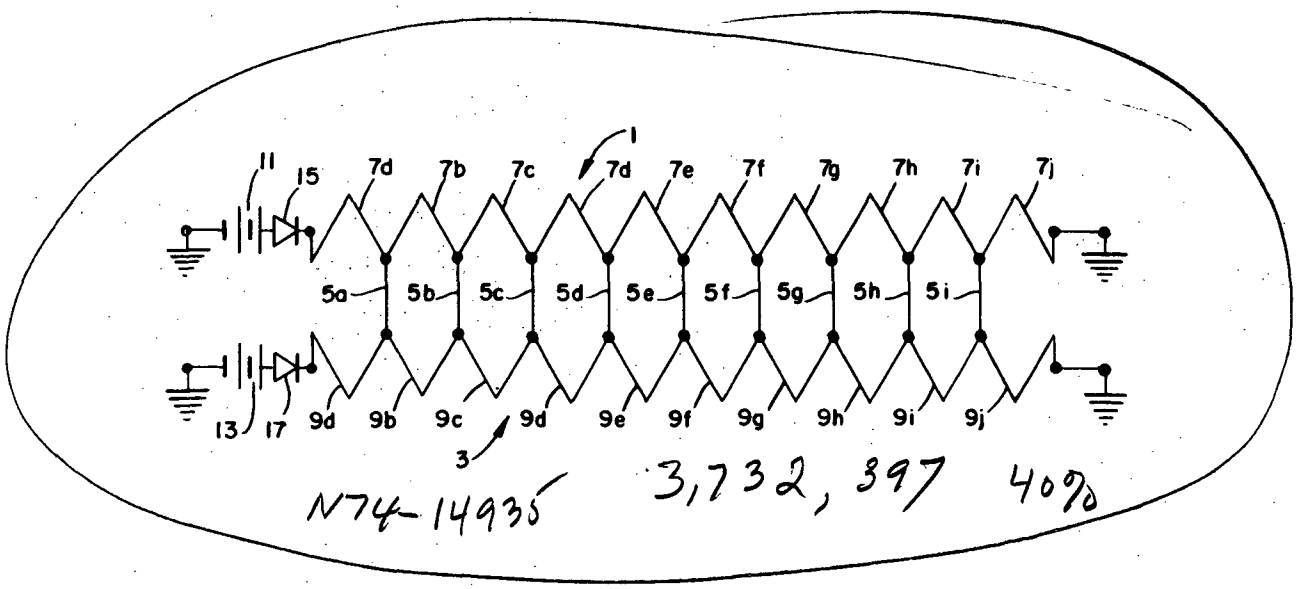

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FIG. 1.

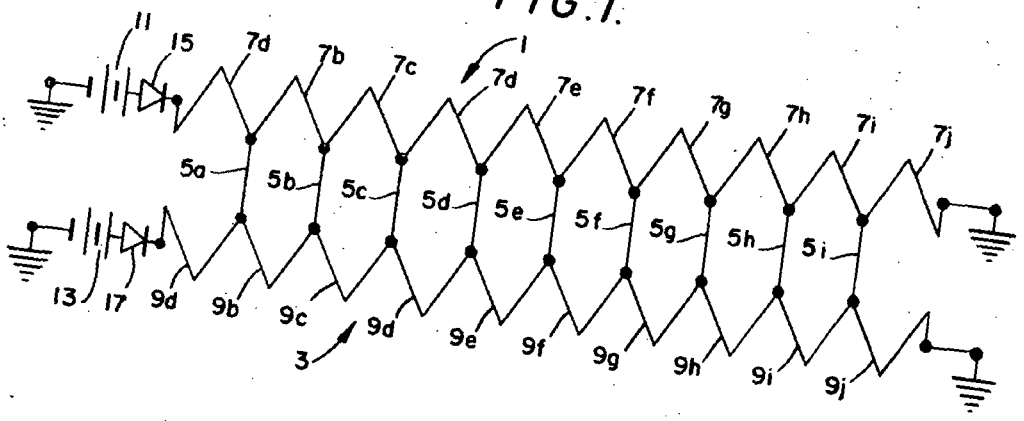


FIG. 2.

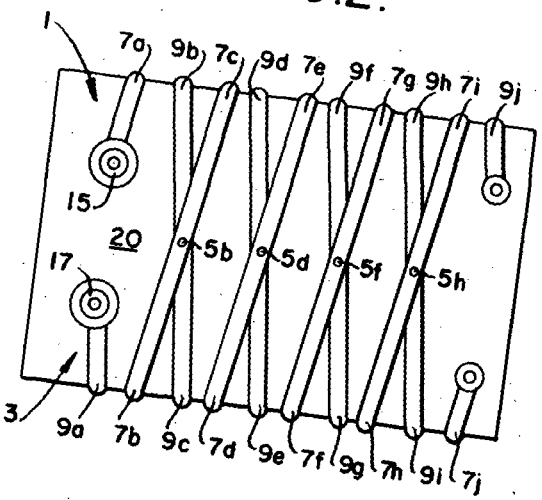
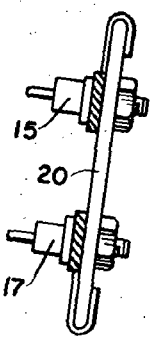


FIG. 3.



INHERENT REDUNDACY ELECTRIC HEATER

ORIGIN OF THE INVENTION

The invention described herein was made in performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; 42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

This invention relates to electrical element heater systems and, more specifically, to such systems constructed to inherently maintain satisfactory output heat after failure of parts of the system.

High reliability of heater operation is necessary in various applications. One field of special interest is that of space flights and the like where repair by human intervention often is not possible and where satisfactiry operation may be of critical importance. An application of particular interest for a high reliability heater is the maintaining of operating temperature in engine computer controls and the like during extended space flights.

Prior systems have employed redundancy or reserve elements to assure satisfactory systems, but the redundancy has required controls and active switching to switch to the back-up system. Such controls incorporate added complexity, expense, and weight into the system and are subject in themselves to failures. The simple use of dual heaters assures some reliability, but electrical power consumption is doubled.

No prior system is known which incorporates inherent redundancy into a plural heater wire system according to the general concepts of this invention.

SUMMARY OF THE INVENTION

It is a primary object of this invention to provide a redundancy heater system which employs no controls or moving parts.

It is, similarly, a primary object of this invention to provide a redundancy heater which operates inherently to provide redundancy.

It is, similarly, an object of this invention to provide a redundancy heater having two, separately operative elements for each essential part.

It is, similarly, an object of this invention to provide a redundancy heater which operates satisfactory regardless of the failure of any one specific part.

It is a more specific object of this invention to provide a redundancy heater having two, isolated power sources.

It is a more general object of this invention to provide a redundancy heater in which power change resulting from the failure of any one element may be 10 percent or less.

In accordance with this invention, two, heater-element wires are provided, which are electrically connected at a number of corresponding points along their length. Two, separate power sources, preferably of the same magnitude, are provided, each connected to one end of the heater wires and directd in the same polarity. The other ends of the wires are grounded or otherwise connected in circuit with the power sources. Operation is without controls or other external influence. Assuming 10, equal-magnitude segments in each of the two wires connected together at corresponding locations, failure of any results in a drop in heat output which may be 10 percent or less of the prior value, depending upon the relative magnitudes of the circuit elements.

A diode is located with a least one power source to block circulating currents through the two sources should their magnitude vary slightly.

It should be understood, of course, within the general concepts of the invention that a single power source could be employed if reliability of that component is considered satisfactory and that the segment ends could be interconnected in various patterns.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic depiction of the preferred system.

FIG. 2 is a side view of an actual, wound bobbin comprising the preferred system.

FIG. 3 is an end view of the bobbin of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The circuit operation may be understood by reference to the schematic representation of FIG. 1. The system is comprised of two heater elements 1 and 3, each of which, by being interconnected at spaced locations by connections 5*a* through 5*i*, is effectively divided into ten segments 7*a* through 7*j* and 9*a* through 9*j*. The heater elements 1 and 3 are identical and the segments 7 and 9 are connected at exactly corresponding points, that is, at locations on the two elements essentially identical electrically. Accordingly, each segment has a heat producing resistance which is one-tenth of that of the full element of which it is a part.

Power sources 11 and 13 are individually connected to the ends of the heater elements 1 and 3, respectively, in complete circuit through an electrical ground. The sources 11 and 13 are identical in magnitude and are individual and separate elements to provide a full redundancy or reserve capability. Diode 15 is connected between source 11 and heater element 1, and diode 17 is similarly connected between source 13 and heater element 3. The diodes 15 and 17 are, of course, unidirectionally conductive devices, and are poled to permit heater current but to block circulating currents between the two sources 11 and 13.

In this preferred embodiment, heater elements 1 and 3 each is 140 ohms in resistance. Accordingly, each segment 7 and 9 is 14 ohms in resistance. Each power source 11 and 13 produces 28 volts DC.

The operation of the system is entirely inherent, without external switching or other activity. When all components are operating normally, the total effective resistance is 70 ohms, presented in complete circuit with 28 volts. Accordingly, by the conventional computation, power output is $V^2/R = (28)^2 170 = 11.2$ watts.

The failure of any one of the twenty segments 7 or 9, leaves the corresponding segment and all other segments in the circuit. For example, a break in segment 7*c* leaves an electrical circuit from the end of segment 7*b* near 7*c*, through connection 5*b* to the end location of segments 9*b* and 9*c*.

The other end location of segment 9*c*, where connection 5*c* is located, is connected with the remainder of the segments of elements 1 and 3 directly or through connection 5*c*.

Accordingly, the 14 ohm resistance of segment 9c appears fully in the circuit when the corresponding segment 7c is open, but the other elements remain in the circuit essentially as previously. Total resistance becomes 77 ohms. The power output is $V^2/R = (28)^2 1 77 = 10.2$ watts, a less than 10 percent variation from the output of the fully operative circuitry.

Voltage sources 11 and 13 are essentially in parallel, except for the first segments 7a and 9a. Accordingly, the loss of any one of the sources 11 and 13 changes the output only by the elimination of the segment 7a or 9a connected to the inoperative source 11 or 13, and the power output would again be 10.2 watts.

FIGS. 2 and 3 illustrate the actual form of construction of the preferred embodiment. The heater system is constructed on a bobbin foundation of a flat, ceramic plate 20. The two heater elements 1 and 3 are wound on the plate 20 in opposite directions and are connected at all crossing points by welds, which constitute the connections 5a through 5i.

The diodes 15 and 17 are integral or mounted on to bobbin 20 so that their heat dissipation adds to the output of the system.

In accordance with the general concepts of the invention, the ends of the segments 7 and 9 could be interconnected in various patterns. Also, a single power source could be employed if reliability of that source is considered satisfactory or if a single source is desirable for other reasons.

Other variations of the invention described will be apparent, and variations may well be developed which employ more than ordinary skill in this art, but nevertheless employ the basic contribution and elements of this invention. Accordingly, patent protection should not be essentially limited by the preferred embodiments disclosed, but should be as provided by law, with particular reference to the accompanying claims.

What is claimed is:

1. An electric heater system with inherent redundancy comprising a first electric heater element and a second electric heater element, at least one of said elements being, effectively, divided into a plurality of electric-heater-element segments, at least one electrical power source, the ends of each of said first and said second elements being electrically connected in circuit with said power source, and different segment-end locations of one of said elements being electrically connected to the other of said elements, each said element when fully operative in the heater being adapted and arranged to produce substantially the same heat in substantially the same locations as the other said element when fully operative.

2. The heater system as in claim 1 in which said ends of said elements are each connected in circuit with separate power supplies and in circuit with at least one unidirectionally conductive device directed to block current flow in a path including said separate power supplies.

3. The heater system as in claim 1 in which both said elements are, effectively, divided into a plurality of electric-heater-element segments and different segment-end locations space electrically along one of said elements are connected to different segment-end locations spaced electrically along the other element.

4. The heater system as in claim 3 in which said ends of said elements are each connected in circuit with separate power supplies and in circuit with at least on unidirectionally conductive device directed to block current flow in a path including said separate power supplies.

5. The heater system as in claim 3 in which both said elements are essentially similar and corresponding segment-end locations in said elements are connected.

6. The heater system as in claim 5 in which said ends of said elements are each connected in circuit with separate power supplies of substantially equal magnitude and in circuit with a least one unidirectionally conductive device directed to block current flow in a path including said separate power supplies.

7. The heater system as in claim 5 in which said elements are wound in different directions on a bobbin foundation and are fused together to form electrical connections at the crossing points of said elements.

8. The heater system as in claim 7 in which said ends of said elements are each connected in circuit with separate power supplies of substantially equal magnitude and in circuit with a least one unidirectional conductive device directed to block current flow in a path including said separate power supplies.

9. The heater system as in claim 8 in which said at least one unidirectionally conductive device comprises two, separate diodes, one of said diodes being connected between one of said power supplies and the said element to which that power supply is connected, the other of said diodes being connected between the other of said power supplies and the said element to which that power supply is connected, and both said diodes being mounted on said bobbin.

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